Alcohols

What are alcohols?

Properties of alcohols

Uses of alcohols

Summary activities
What are alcohols?

Alcohols are a family of organic compounds that contain carbon, hydrogen and oxygen atoms.

They are **not** hydrocarbons, because they contain oxygen.

The defining feature of alcohols is the **functional group** –OH.

For example:

- Methanol ($\text{CH}_3\text{OH}$)
- Ethanol ($\text{C}_2\text{H}_5\text{OH}$)
- Propan-1-ol ($\text{C}_3\text{H}_7\text{OH}$)
Naming alcohols

Alcohols are a **homologous series**. The name of an alcohol is derived from the number of carbon atoms in the compound and ends with **–ol**.

<table>
<thead>
<tr>
<th>number of carbons</th>
<th>name of alcohol</th>
<th>chemical formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>methanol</td>
<td>CH₃OH</td>
</tr>
<tr>
<td>2</td>
<td>ethanol</td>
<td>C₂H₅OH</td>
</tr>
<tr>
<td>3</td>
<td>propanol</td>
<td>C₃H₇OH</td>
</tr>
<tr>
<td>4</td>
<td>butanol</td>
<td>C₄H₉OH</td>
</tr>
</tbody>
</table>

Can you work out the general formula for alcohols?

The general formula of alcohols is **CₙH₂n+₁OH**.
Determining the formulae of alcohols

Example: 1/4
What is the structural formula of an alcohol with the molecular formula C₂H₅OH?
Identifying alcohols

Are these alcohols?

- Alcohol
- Not an alcohol

Methanol
Alcohols

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The table below shows the boiling points of the first four alkanes and alcohols. Press "play" to explore this data.

<table>
<thead>
<tr>
<th>alkane</th>
<th>boiling point</th>
<th>alcohol</th>
<th>boiling point</th>
</tr>
</thead>
<tbody>
<tr>
<td>methane</td>
<td>-164 °C</td>
<td>methanol</td>
<td>65 °C</td>
</tr>
<tr>
<td>ethane</td>
<td>-88 °C</td>
<td>ethanol</td>
<td>79 °C</td>
</tr>
<tr>
<td>propane</td>
<td>-42 °C</td>
<td>propan-1-ol</td>
<td>98 °C</td>
</tr>
<tr>
<td>butane</td>
<td>0 °C</td>
<td>butan-1-ol</td>
<td>117 °C</td>
</tr>
</tbody>
</table>
Intermolecular forces

All molecules are held together by **intermolecular forces**.

These forces must be overcome in order for a substance to turn into a gas (boil).

The intermolecular forces between alcohol molecules are relatively strong because the –OH groups attract each other.

Greater amounts of energy are needed to separate the molecules. This means that alcohols have relatively high boiling points compared to alkanes of the same length.
Reactivity of alcohols

How do alcohols, alkanes and water react?

Reaction with sodium

Use the tongs to pick up and then drop a piece of sodium into each dish.

What happens to each substance?
Reaction of alcohols with oxygen

Because alcohols contain hydrocarbon chains, they often react in a similar way to alkanes.

For example, ethanol burns in oxygen to form carbon dioxide and water:

\[
\text{ethanol} + \text{oxygen} \rightarrow \text{carbon dioxide} + \text{water}
\]

\[
C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O
\]

What is the equation for the reaction of hexane with oxygen?

\[
\text{hexane} + \text{oxygen} \rightarrow \text{carbon dioxide} + \text{water}
\]

\[
2C_6H_{14} + 19O_2 \rightarrow 12CO_2 + 14H_2O
\]
Reaction of alcohols with sodium

Because alcohols contain an –OH functional group, they often react in a similar way to water.

For example, ethanol reacts with sodium to form sodium ethoxide and hydrogen:

\[
2\text{C}_2\text{H}_5\text{OH} + 2\text{Na} \rightarrow 2\text{C}_2\text{H}_5\text{ONa} + \text{H}_2
\]

What is the equation for the reaction of water with sodium?

\[
2\text{H}_2\text{O} + 2\text{Na} \rightarrow 2\text{NaOH} + \text{H}_2
\]
The solubility of alcohols in water is affected by both the –OH functional group and the hydrocarbon chain.

The –OH functional group enables small alcohols to fully dissolve in water to form a neutral solution. The larger alcohols have longer hydrocarbon chains, and are therefore less soluble in water.
Alcohols

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Uses of ethanol

Alcohols have a wide variety of uses, with different alcohols being better suited to some uses than others.

**Ethanol** is the alcohol that is used to make alcoholic drinks.

Alcoholic drinks vary in the percentage of ethanol that they contain.

Why is ethanol used for alcoholic drinks rather than a different type of alcohol?

Ethanol also has antibiotic properties, so is often used in antibacterial hand wipes.
Ethanol can be used as a fuel for cars and other vehicles.

**Bioethanol** is produced by the natural fermentation of the carbohydrates in sugar beet, sugar cane or wheat crops.

Bioethanol is sold as E85 fuel, which contains 85% bioethanol and 15% petrol. It can be used by cars that have modified fuel systems, and reduces carbon dioxide emissions by 70%.

What are the advantages and disadvantages of using bioethanol as a fuel?
Ethanol can be oxidized to make ethanoic acid, which is the main acid present in vinegar. Vinegar is a dilute solution of ethanoic acid.

Ethanoic acid can be made from ethanol by naturally occurring microbes. If a bottle of wine is left open for several days it will begin to change into vinegar.

Vinegar is used as a flavouring for food, for example, in salad dressing.

Vinegar can also be used as a food preservative.
Uses of methanol

Methanol is a commonly used **solvent**. Alcohols make useful solvents because the –OH group causes part of the molecule to have a slight positive charge and part to have a slight negative charge. This means that ionic compounds will dissolve in them.

Alcohols are often used as solvents in paint. They boil at a lower temperature than water, so they evaporate quickly to leave the dry pigment behind.
Using alcohols as a fuel

"The manufacture of bioethanol from plants causes land to be diverted from food production. Also, the manufacturing process requires energy, which is currently provided by fossil fuels."

"Anything that reduces our current dependence on fossil fuels has to be a good thing. Bioethanol is made from a renewable resource and produces fewer pollutants than petrol during combustion."
Alcohols

- What are alcohols?
- Properties of alcohols
- Uses of alcohols
- Summary activities
<table>
<thead>
<tr>
<th></th>
<th>Are these statements about alcohols true or false?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Alcohols are hydrocarbons.</td>
</tr>
<tr>
<td>2.</td>
<td>Propanol contains 3 carbon atoms, 8 hydrogen atoms and 1 oxygen atom.</td>
</tr>
<tr>
<td>3.</td>
<td>Methanol has the formula, CH₃CH₂OH.</td>
</tr>
<tr>
<td>4.</td>
<td>Alcohols are useful as solvents because they burn in air to form carbon dioxide and water.</td>
</tr>
<tr>
<td>5.</td>
<td>Ethanol has a higher boiling point than ethane.</td>
</tr>
</tbody>
</table>
Glossary of keywords: alcohols

**alcohol** – A group of organic compounds which contain hydrogen, carbon and oxygen, with the functional group –OH.

**bioethanol** – A fuel produced from the fermentation of plant material.
Multiple-choice quiz

Is your knowledge functional enough to ace this quiz on alcohols?

Press "start" to begin.

start